FASE DE ANÁLISIS ORIENTADO AL PROBLEMA DENTRO DEL PROCESO DE CONCEPTUALIZACIÓN DE REQUERIMIENTOS

PROBLEM-ORIENTED ANALYSIS PHASE WITHIN PROCESS OF CONCEPTUALIZATION OF REQUIREMENTS

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RESUMEN

El proceso de educación de requisitos, cuyo objetivo central consiste en dar a luz a los requisitos, no solo constituye un proceso de carácter técnico para construir un determinado sistema, sino también un proceso con importantes connotaciones de tipo social que involucra a distintas personas (stakeholders); circunstancia ésta que origina que se presenten ciertos problemas a la hora de la realización de dicho proceso de conceptualización. Se ha propuesto un proceso de conceptualización de requerimientos que se estructura en dos fases: (a) Análisis Orientado a Problemas, que tiene el fin de comprender el problema dado por el usuario en el dominio, y (b) Análisis Orientado a Productos, que tiene el fin de obtener las funcionalidades que los usuarios desean recibir en el producto software a ser desarrollado, teniendo en cuenta las relaciones de estas características con la realidad expresada por el usuario en su discurso. Una prueba de concepto es dada para la fase de Análisis Orientado a Problemas.

Palabras Claves: Proceso de Educación de Requerimientos, Análisis Orientado a Problemas, Análisis Orientado a Productos, Ingeniería de Requerimientos, Modelos Conceptuales.

ABSTRACT

The requirements elicitation process, whose main objective is to give birth to the requirements, not only is a technical process to build a particular system but also an important process of social connotations involving different people (stakeholders), a circumstance which causes certain problems arise when carrying out this process of requirement conceptualization. A process of conceptualization of requirements is proposed that are structured in two phases: (a) Problem-Oriented Analysis: aimed at understanding the problem given by the user in the domain in which this takes place, and (b) Product-Oriented Analysis: its aim is to obtain the functionalities that the user intends to obtain from the software product to be developed, taking into account the relationship of these features with the reality expressed by the user in his speech. A proof of concept is given for the Problem Oriented Analysis Phase.

Keywords: Requirements elicitation process, Problem-Oriented Analysis, Product-Oriented Analysis, Requirement Engineering, Conceptual Modelling.

INTRODUCCIÓN

The requirements elicitation process, whose main objective is to give birth to the requirements, not only is a technical process to build a particular system but also an important process of social connotations [22] that involves different people (stakeholders). It is usual that the process of requirements elicitation causes problems when it is been carrying out [5]. Similarly, with regard to the stakeholders it is clear that the term is used in reference to any person or group that is affected by the system directly or indirectly, between them can be cited to end users who interact with the system and as well as others who may be affected by the implementation of it (maintenance professionals providing other related systems, experts in the domain of the system, business managers, others).

The aforementioned problems can be addressed based on the disadvantages to which the requirements engineers faced when conditions surveying and understanding the requirements that show the different stakeholders are focused [20]. These problems can be summarized as follows:

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In most cases, stakeholders know what they want to get the information system, finding it difficult to express what the problem is seeking to be resolved and, consequently, what they want the system to do.

In general, stakeholders express their requirements with your own natural language and with an implicit knowledge of their own work. Therefore, requirements engineers should properly understand these requirements (although in most of the cases lack the experience and knowledge in the user's domain).

Most likely, the different stakeholders involved in building the system having different requirements, which can be expressed in several different ways. Therefore, requirements engineers must take into account all possible sources of requirements and find potential matches and conflicts.

It is also possible that political factors have some influence on system requirements. For example, a director of a department may request the system requirements for the purpose of having greater influence within the organization.

Following this line, for the exposed reasons we can say that the process of requirements elicitation is difficult to perform. In this sense, according to Christel [7] and the idea of supplementing the problems set forth above, it is considered advisable to add the following considerations:

- A lot of important information for building the software product fails to be verbalized by stakeholders, thus leaving important gaps reflected in the captured information.
- In most cases the process of requirements elicitation takes place in relation to a passive user, when in reality must be addressed cooperatively among user and requirements engineer.

Now, in light of all the constraints that make mention Sommerville and Christel, proper of requirements elicitation process is that there is a need to explore and analyse those features that are inherent to this process and, as such, contribute to characterize the process. Characterized the task of requirement elicitation, it follows that the axis of it focuses on establishing communication between the user and the Requirements Engineer. This, when developing their work in elicitation, you must capture and model a reality that frames a problem, whose solution must be approached through a software product. Since this is really an intangible element, usually too complex, it is also difficult to capture.

However, capturing this reality together with its problems are reflected in the user's speech, from which the requirements engineer must make the universe of the discourse ("situations, events, objects, etc."); in which focuses the study for the elicitation and therefore prove to be essential to addressing the future software development [25]), for the purpose of achieving conceptual models during the stage of requirements analysis.

These problems, taken from the elicitation process, make it difficult for the Requirements Engineer develop the stakeholder universe of discourse, as well as the construction of adequate conceptual models [17] [24], i.e. these problems, which begin to manifest themselves in the process from requirements elicitation and communication between the user and the engineer, probably will be propagated in the activity of construction of conceptual models. These drawbacks inexorably converge towards obtaining low-quality software [27].

In this context, the problem is focused (Section 2), we propose a process of requirements conceptualization (Section 3), a concept proof of phase problem-oriented analysis is given (section 4), and conclusions and future research work is outlined.

PROBLEM DESCRIPTION

The open problem identified in this section, is the need to structure and categorize the mass of information coming from the elicitation process. The purpose is facilitating the understanding of the problem expressed by the user [8] [9] [16], in other words, to conceptualize the requirements. Inadequate treatment of the complexity contained in the user's discourse has been highlighted by several authors [2] [5] [8] [9] [12] [14] [15] [23] [26] [25]. These authors mention the difficulties in building conceptual models based on the information contained in the elicitation process and reflected in the user's speech. Also worth noting that these difficulties give the analysis process to a degree of immaturity which makes it difficult to perform effectively in this activity, while difficult to adopt this approach in organizations [19] . Accordingly and pursuant to the foregoing, the open problem addressed in this paper, is a "perception gap" [8] [21] [23] in the transition of a process (requirements elicitation) to another process (Conceptual Modelling). This concept is illustrated in Figure 1.

Figure 1. “Gap” among Requirements Elicitation and Conceptual Modelling

Because of this, is clearly a need to conceptualize the requirements stated by the user in his speech before
going to the construction of conceptual models in order to reduce complexity and promote understanding referred to the problem described by the user, contributing to the achievement of better quality of Conceptual Models [6] [24]. It is important to note the very small number of papers related to the development of intermediate representations of the flows of information obtained by the Requirement Engineering in the process of elicitation. In other words jobs that are oriented toward the pursuit of reducing the complexity of reality and its problems expressed by the user in his speech. Fundamental principles of structuring information (partition, abstraction, projection) provide a knowledge structure in order to contribute to a simplified view of reality and its problems [8]. While these principles provide their input to clarify the effects of a better understanding of their requirements are very general and low level of detail.

**PROPOSAL OF PROCESS OF CONCEPTUALIZATION OF REQUIREMENTS**

The solution proposed in this work involves the insertion of an activity of Conceptualization of Requirements, which aims to act as a bridge or link ("link") between the activities of requirements elicitation and the activities conceptual modelling, thereby facilitating the understanding of the problem expressed by the user and therefore obtain higher quality Conceptual models [5] [6] [8] [15] [24]. The illustration of this idea can be displayed on the figure 2 and which shows the absence of the "gap", which is replaced by the activity of Conceptualization of Requirements.

![Figure 2. Inserting the activity of "Conceptualization of Requirements" between the activities of Requirements elicitation and Conceptual Modelling](image)

Since the implementation of this activity conceptualization of requirements is possible to achieve a set of intermediate representations of user requirements, from which it is possible to "characterize" the information contained in the speech of the user (usually in a "natural language" and that is how it is presented in this paper), to have an easier process to build conceptual models. These intermediate representations are formed mainly by a set of graphical representations: Refined User Scenarios, which appropriately linked through the Unified Map of User Scenarios allow the user to characterize the discourse in a way alternative to traditional natural language. It is important to note that when you refer to the User Scenarios is meant that they already were reviewed jointly by the requirements engineer and the user before final approval.

The process of conceptualizing the proposed requirements is done through a process called Requirements Conceptualization Process which is developed in two phases: (a) Problem-Oriented Analysis, whose goal is to understand the problem posed by the user in the domain in which this takes place, and (b) Product-Oriented Analysis, whose goal is to obtain the functionality that the user intends to obtain from the software product to be developed, taking into account the relationship of these features with the reality expressed by the user in his speech. Figure 3 represents the process of conceptualization of requirements with focus on interdependence between the phases, tasks and products. Phase Problem Oriented Analysis is divided into three tasks:

(a) "User Discourse/Speech Segmentation",
(b) "Cognitive Analysis of Text Segments",
and
(c) "Construction of Problem Space based on User Scenarios".

The "Discourse of Natural Language User" (which from now on in this paper we will call user speech) is the input for the task "User Discourse/Speech Segmentation" that results in the "Text Segments". These segments are the input to task, "Cognitive Analysis of the Text Segments" generating the respective "Knowledge Types". The "Text Segments" and "Knowledge Types" are the inputs for the task "Construction of Problem Space based on User Scenarios" that will result in "Problem Space based on User Scenarios".

Phase Product-Oriented Analysis is divided into three tasks:

(a) "Construction of Users Scenario",
(b) "Refinement of Scenarios User",
and
(c) "Construction of the Unified Map of User Scenarios".

The "User Speech", the "Text Segments" and the "Problem Space based on User Scenarios" constitute the inputs for the task "User Scenario Construction". These scenarios along with the "User Speech" respectively are the input to task "Refinement of Scenarios User" that generates the respective "Refined User Scenarios". These, and "Text Segments" are the inputs of the task "Construction of the Unified Map User Scenarios", that result in the "Unified Map User Scenarios". The techniques and representations of the tasks in the problem-oriented analysis phase are summarized in Figure 4.
Figure 3. Process of requirements conceptualization; detailing: stages, tasks and products

<table>
<thead>
<tr>
<th>PHASE</th>
<th>TASK</th>
<th>INPUT PRODUCTS</th>
<th>TRANSFORMATION TECHNIQUE TO BE USED</th>
<th>OUTPUT PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROBLEM ORIENTED ANALYSIS</strong></td>
<td><strong>User Discourse / Speech Segmentation</strong></td>
<td>• User Discourse / Speech (DU)  • Text Segments (ST)</td>
<td>Protocols Analysis (AP)</td>
<td>Text Segments Templates (T-ST)</td>
</tr>
<tr>
<td></td>
<td><strong>Cognitive Analysis of Text Segments (ACST)</strong></td>
<td>• Text Segments Templates (TST)  • Knowledge Types (TC)</td>
<td>Identification Cognitive Technique for Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge (T-TCI-FPA)</td>
<td>Knowledge Types (TC)  • Knowledge Types Templates (T-TKI-FPA)</td>
</tr>
<tr>
<td></td>
<td><strong>Construction of Problem Space based on User Scenarios (CEPSEU)</strong></td>
<td>• Text Segments Templates (T-ST)  • Template of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge (T-TCI-FPA)</td>
<td>Technique for Construction of Problem Space based on User Scenarios</td>
<td>Problem Space based on User Scenarios (EPEU)  • Diagram of Problem Space based on User Scenarios (EPEU)</td>
</tr>
</tbody>
</table>

Figure 4. Phase, task and products
A CONCEPT PROOF OF PHASE PROBLEM-ORIENTED ANALYSIS

This section presents the example of a Fuel Supply System of Aircraft as concept proof of the phase "Problem-Oriented Analysis". For each task, the inputs and outputs are described and the used techniques. There are described: the Task User Discourse / Speech Segmentation, the Task Cognitive Analysis of Text Segments and the Task Construction of Problem Space based on User Scenario.

Task User Discourse / Speech Segmentation

The result of the task may be seen in figure 5.

Task Cognitive Analysis of Text Segments

This section shows the results of cognitive techniques that have been applied to identify factual knowledge, procedural knowledge, and contextual knowledge and association knowledge with the Text Segments obtained in previous section. The result of the task may be seen in figure 6.

Task: TASK USER DISCOURSE / SPEECH SEGMENTATION

Input:

User's Speech

The procedure to be carried out for the fueling management of aircraft operating at the airport. It must be considered some aspects that make the operation context in this regard. First, the Airport Control Administration (ACA) should establish contact with the two towers of Control (TC) responsible for managing the process of refueling in the field for that purpose. To this end, the ACA must communicate to the TC (each TC has an identifier number) when the supply operation can start. In turn, both towers are also interconnected. Towers of Control authorized to begin the procurement process, begin it when the aircraft (A) enters the supply sector which must have identification, know its location (i.e.: a particular Hangar), whether or not mechanical maintenance done and if their engines are turned on or not, also, the A must be authorized by one of the TC for procurement and the TC must approve the request and notify to A. In turn, the TC order authorizing the supply of A, it must have made the mechanical maintenance. By side, the type of communication between the Towers of Control and aircraft can be Simplex, Duplex or Full-Duplex. Once A has been authorized to carry out the water procurement procedure A may ordered to move from its current place (i.e.: Hangar No. 1) to the water tank supply location (TA). It is clear that for the A to move their engines must be turned on and A movement is in a certain velocity.

Technique: Protocol Analysis (AP)

Output:

Text Segment [1]: Identifies a first user scenario (EU) which represents the Initial Contextual Framework

The procedure to be carried out for the fueling management of aircraft operating at the airport. It must be considered some aspects that make the operation context in this regard. First, the Airport Control Administration (ACA) should establish contact with the two towers of Control (TC) responsible for managing the process of refueling in the field for that purpose. To this end, the ACA must communicate to the TC (each TC has an identifier number) when the supply operation can start. In turn, both towers are also interconnected. Towers of Control authorized to begin the procurement process, begin it when the aircraft (A) enters the supply sector which must have identification, know its location (i.e.: a particular Hangar), whether or not mechanical maintenance done and if their engines are turned on or not, also, the A must be authorized by one of the TC for procurement and the TC must approve the request and notify to A. In turn, the TC order authorizing the supply of A, it must have made the mechanical maintenance. By side, the type of communication between the Towers of Control and aircraft can be Simplex, Duplex or Full-Duplex.

Text Segment [2]: Identifies a second user scenario (EU) that represents the entrance of an aircraft supply sector

Tower of Control authorized to begin the procurement process, begin it when the aircraft (A) enters the supply sector which must have identification, know its location (i.e.: a particular Hangar), whether or not mechanical maintenance done and if their engines are turned on or not, also, the A must be authorized by one of the TC for procurement and the TC must approve the request and notify to A. In turn, the TC order authorizing the supply of A, it must have made the mechanical maintenance. By side, the type of communication between the Towers of Control and aircraft can be Simplex, Duplex or Full-Duplex.

Text Segment [3]: Identifies a third user scenario (EU) which represents the movement of an aircraft to the water supply

Once A has been authorized to carry out the water procurement procedure A may ordered to move from its current place (i.e.: Hangar No. 1) to the water tank supply location (TA). It is clear that for the A to move their engines must be turned on and A movement is in a certain velocity.

Figure 5. Results of applying Task User Discourse / Speech Segmentation
**Task:** COGNITIVE ANALYSIS OF TEXT SEGMENT [1]

**Input:** Text Segment [1]

**Technique:** Cognitive Techniques for Identification of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge.

**Output:**

<table>
<thead>
<tr>
<th>FACTUAL KNOWLEDGE</th>
<th>ACTORS</th>
<th>NAME</th>
<th>ATTRIBUTE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Airport Central Administration</td>
<td>Identification</td>
<td>ACA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tower of Control 1</td>
<td>Number</td>
<td>TC1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tower of Control 2</td>
<td>Number</td>
<td>TC2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RELATIONSHIPS</th>
<th>NAME</th>
<th>ACTORS LINKED BY RELATIONSHIP</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comunicated</td>
<td>- Tower of Control 1</td>
<td>This relationship indicates that both control towers are interconnected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Tower of Control 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contact</td>
<td>- Tower of Control 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Tower of Control 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>This relationship indicates that the Airport Central Administration makes contact with the two towers of Control (TC) responsible for managing the process of refueling supply</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROCEDURAL KNOWLEDGE</th>
<th>Not identified in the segment analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTEXTUAL KNOWLEDGE</td>
<td>Identifying a baseline scenario where takes place the facts of reality expressed by the user and in which there are two actors relevant to this reality: the Airport Central Administration (ACA) and the Control Towers (CT) with their respective relationships</td>
</tr>
<tr>
<td>ASSOCIATION KNOWLEDGE</td>
<td>Not identified in the segment analyzed</td>
</tr>
</tbody>
</table>

Figure 6.a. Results of applying Task Cognitive Analysis of Text Segments

**Task:** COGNITIVE ANALYSIS OF TEXT SEGMENT [2]

**Input:** Text Segment [2]

**Technique:** Cognitive Techniques for Identification of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge.

**Output:**

<table>
<thead>
<tr>
<th>FACTUAL KNOWLEDGE</th>
<th>ACTORS</th>
<th>NAME</th>
<th>ATTRIBUTE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aircraft</td>
<td>Identification</td>
<td>has a value, for example 341102048</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Location</td>
<td>NT1 takes a value for a given time, such as Hangar No. 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mechanical Maintenance</td>
<td>takes a value for a given time, such as realized or unrealized</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supply Authorization</td>
<td>takes a value for a given time, such as affirmative</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engine Status</td>
<td>takes a value for a given time, such as turn on or turn off</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tower of Control 1</td>
<td>Number</td>
<td>TC1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tower of Control 2</td>
<td>Number</td>
<td>TC2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RELATIONSHIPS</th>
<th>NAME</th>
<th>ACTORS LINKED BY RELATIONSHIP</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comunicated</td>
<td>- Tower of Control 1</td>
<td>This relationship indicates that both control towers are interconnected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Tower of Control 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROCEDURAL KNOWLEDGE</th>
<th>INTERAKTIONS</th>
<th>NAME</th>
<th>ACTORS INVOLVED IN THE INTERACTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Authorization Request</td>
<td>- Aircraft</td>
<td>Through this interaction the actor Aircraft requesting authorization to refuel actor Tower of Control 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tower of Control 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Authorization Approved</td>
<td>- Tower of Control 1</td>
<td>Through this interaction, the actor Tower of Control 1 makes a decision (assuming the affirmative in this case) on the authorization request and informs the actor Aircraft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Aircraft</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Both interactions have the attribute referred to the type of communication that can be Simplex, Duplex or Full-Duplex, in turn, the condition that must be accomplished for these interactions take place is that the aircraft has the Mechanical Maintenance Done.

<table>
<thead>
<tr>
<th>CONTEXTUAL KNOWLEDGE</th>
<th>Not identified in the segment analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSOCIATION KNOWLEDGE</td>
<td>Not identified in the segment analyzed</td>
</tr>
</tbody>
</table>

Figure 6.b. Results of applying Task Cognitive Analysis of Text Segments
In this section we present the results of having applied the technique of construction of diagram of problem-space based on user scenarios to templates of factual knowledge, procedural knowledge, contextual knowledge and association knowledge obtained in previous section. The result of the task may be seen in figure 7.

### CONCLUSIONS

The main contribution of this paper is to present a methodical process called Conceptualization of Requirements, which is divided into two phases, called the Problem Oriented Analysis and Product-Oriented Analysis and whose main objective is to structure and characterize the mass of information from elicitation activity within the discourse (speech) of the user.

This paper presents a proof of concept for a specific case of the first phase of this process, which has as input the text associated to the User’s Speech (DU) and as an
output the Diagram of Problem-Space Based on User Scenarios. This diagram is formed by the central elements of User’s Speech (actors, attributes, relationships, interactions, actions, others) for display in graphical way the thinking of user with respect to the problem.

Task: CONSTRUCTION OF PROBLEM SPACE BASED ON USER SCENARIOS (Text Segment [1])

Input:
- Text Segment [1]
- Template of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge obtained from Text Segment [1]

Technique: Technique of Construction of Diagram of Problem-Space Based on User Scenarios

Output:

Task: CONSTRUCTION OF PROBLEM SPACE BASED ON USER SCENARIOS (Text Segment [2])

Input:
- Text Segment [2]
- Template of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge obtained from Text Segment [2]

Technique: Technique of Construction of Diagram of Problem-Space Based on User Scenarios

Output:

Figure 7 Results of applying Task Construction of Problem Space based on User Scenarios

To carry out the tasks it has been adapted some techniques and developed another ones; they are: Protocol Analysis, Cognitive Techniques for Identification of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge, and Technique of Construction of Diagram of Problem-Space Based on User Scenarios.

The structuration of the Phase of Problem Oriented Analysis into the tasks: User Discourse / Speech Segmentation, Cognitive Analysis of Text Segments and Construction of Problem Space based on User Scenarios; allows the requirements engineer to carry out a systematic analysis of user's speech to reach gradually an integrated representation of the fundamental elements of it.

The next research steps are: (a) to focus on implementing the second phase of the proposed conceptualization process (Product-Oriented Analysis) is also envisioned as necessary to carry out three tasks: Construction of Users Scenario, Refinement of User Scenarios and Construction of the Unified Map of User Scenarios; and (b) develop and execute an experiment to
validate empirically the process of conceptualization of requirements introduced.

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